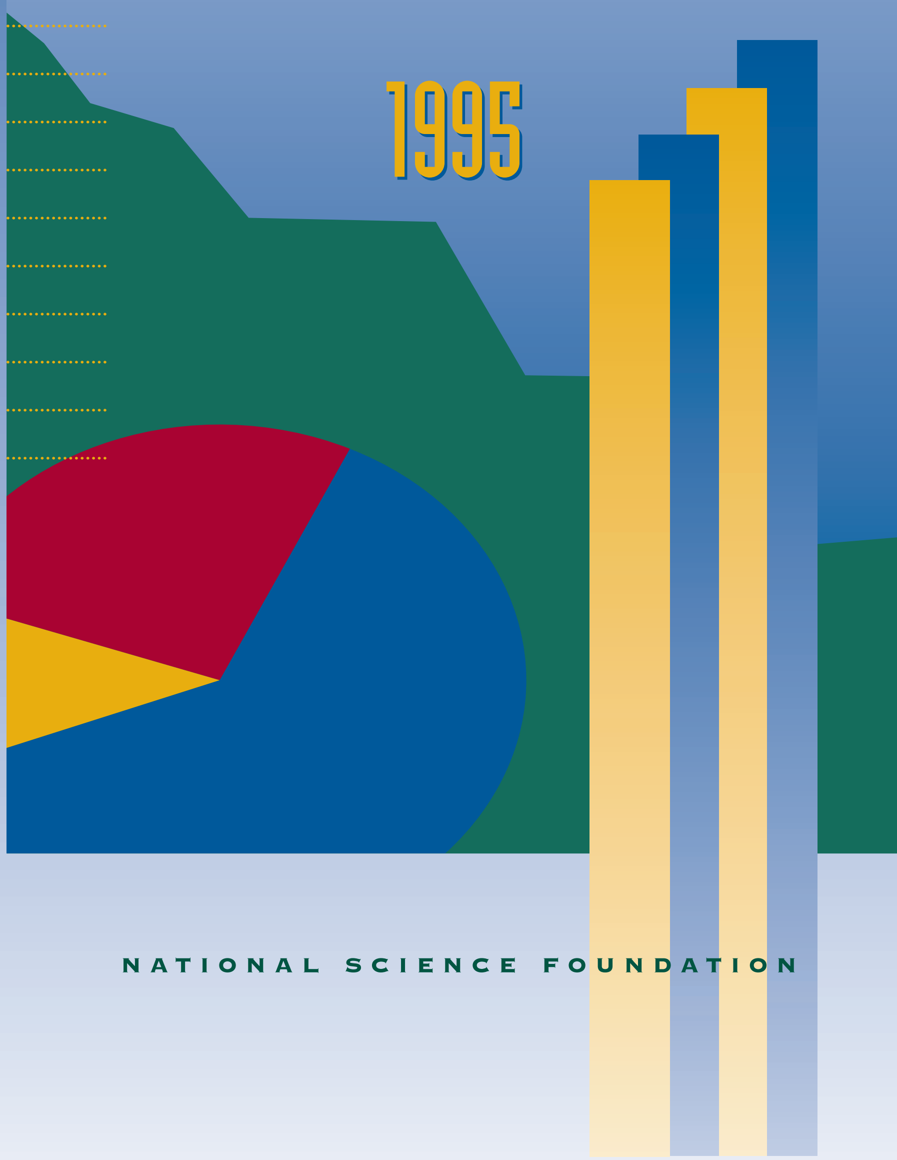
Indicators of Science & Mathematics Education

1995



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Indicators of Science and Mathematics Education 1995

January 1996

REC Indicators Series

National Science Foundation

Recommended Citation

Division of Research, Evaluation, and Communication, Directorate for Education and Human Resources, *Indicators of Science and Mathematics Education 1995*. Edited by Larry E. Suter. Arlington, VA: National Science Foundation, 1996 (NSF 96-52).

Acknowledgments

This report was planned and prepared in the Directorate for Education and Human Resources (EHR), Luther S. Williams, Assistant Director. Daryl E. Chubin, Division Director of the Division of Research, Evaluation, and Communication, provided general direction and oversight. Larry E. Suter, Deputy Director of the division, was responsible for directing the writing and production of the report. An advisory committee reviewed the outlines, preliminary indicators, and drafts of the chapters. Members of the advisory committee were Bernice Anderson, Educational Testing Service; Elinor Barber, Columbia University; Bill Honig, San Francisco State University; Daniel Koretz, the Urban Institute; and Terrence Russell, the Association for Institutional Research and Florida State University. The *Indicators of Science and Mathematics Education 1995* was written by

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Under contract to the Directorate for Education and Human Resources, Friday Systems Services provided the following services in the production of this document: research, statistical analysis, editing, design, data entry, graphics creation, quality control, and desktop publishing. Kaarin Engelmann was managing editor. Other Friday Systems Services staff included Megan Henley Kinney, Beverly Stark, So Young Kim, Ramona Winkelbauer, and Todd Phillips.

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Highlights

Since its establishment in 1950, one of NSF's missions has been to provide research, guidance, and support for U.S. science and mathematics education. NSF's role extends into the compilation of statistical data about science and mathematics education programs gathered by Federal agencies, such as the National Center for Education Statistics. NSF analyzes statistical information from outside sources, as well, and develops appropriate methods for evaluating the effectiveness of programs and initiatives. Creation of a biennial science and mathematics education indicator report,[1] therefore, builds on the agency's leadership as compiler, reviewer, and interpreter of complex data.

While the 1992 Indicators report primarily described science- and mathematics-education-related trends from 1970 to 1990, this latest document focuses, wherever possible, on information regarding student proficiency, curricula, learning environments, demographics, and so forth, that has been gathered through 1993. Therefore, this report serves as an update on the ways in which the important issues in science and mathematics education, analyzed in the 1992 edition, continue to change.

A review of major reports recommending an indicator system for monitoring science and mathematics education is presented in the Postscript of this report. That section also recommends new, future directions for collection and presentation of such indicators.

Major sources of the latest data include such existing national surveys as the National Assessment of Educational Progress (NAEP), the National Education Longitudinal Study of 1988, the National Survey of Science and Mathematics Education, and High School and Beyond. The main source for international comparisons is the International Assessment of Educational Progress. In some cases, the authors have conducted secondary analyses of the existing data, but no new data have been collected by NSF for this report.

A full understanding of the data presented here requires some familiarity with the precepts of systemic reform in science and mathematics education and the standards upon which the concept is based. It is largely within this context that the subjects of the report—student achievement, the competency of teachers, the sophistication of the learning environment, and others—have been selected.

Standards and Systemic Reform

Over the past decade, science and mathematics education standards, which provide an explicit set of expectations for teaching and learning, have been articulated by a number of prestigious organizations, such as the National Council for Teachers of Mathematics, the National Research Council, the National Science Teachers Association, and the American Association for the Advancement of Science. While differing in details, the standards are consistent in providing guidelines for instruction, calling for improvement in teacher qualifications and the learning environment, and setting levels of expectation for student achievement. The standards reinforce the notion that the pursuit of excellence must be open to all students, regardless of their sex, their race, or the community in which they live.

The standards have, in turn, yielded a widely endorsed set of specific goals, such as the following:

- All students should be expected to attain a high level of scientific and mathematical competency.
- Students should learn science and mathematics as active processes focused on a limited number of concepts.
- Curricula should stress understanding, reasoning, and problem solving rather than memorization of facts, terminology, and algorithms.
- Teachers should engage students in meaningful activities that regularly and effectively employ calculators, computers, and other tools in the course of instruction.
- Teachers need both a deep understanding of subject matter and the opportunity to learn to teach in a manner that reflects research on how students learn.

Meeting the standards and goals of excellence and equity requires a broadly based, coherent, systematic approach. NSF and the Department of Education have

[1]As specified in the Senate 1991 Appropriations Bill (HR 5158), this report is a congressionally mandated one:

"…In addition, the Committee expects the [National Science] Foundation to establish a biennial science and mathematics education indicator report, distinct from the science and engineering indicator report, that evaluates the progress of the United States in improving the science and mathematics capability of its students, and the effectiveness of all Federal and State education programs as part of this process."

collaborated on a number of systemic reform efforts that entail a coordinated national initiative, as opposed to piecemeal remedial efforts, to address all components of the prevailing educational system.

Systemic science and mathematics education reform is built on the following elements:

- Curricular reform for all students at all grade levels, including the establishment of achievement standards based on the ability to master scientific processes, rather than memorization of facts or formulas;
- Changes in the learning environment, including pedagogic reform, with teachers emphasizing active student involvement through discussion, problem solving, hands-on activities, and small-group work;
- More opportunities for all students to use calculators and computers in the classroom and for homework;
- More exposure of low-achieving students to the full range of educational opportunities and demands; and
- Assessment reform that replaces tests based on factual knowledge with tests that measure the ability to reason, solve problems, and use scientific principles.

Observations

This report covers characteristics of elementary, secondary, and postsecondary education. The indicators were selected to show evidence of change in the Nation's science and mathematics education system. For elementary and secondary education, the selection of indicators includes curriculum coverage, teacher practices, and student achievement. This selection was influenced by national standards, which were developed by professional education associations. For postsecondary education, the selection of indicators monitors the extent of access to science and engineering postsecondary education by underrepresented minorities and females.

Overall, the trends toward higher student performance and course completion are consistent with the goals of reform. Some significant observations of changes during the past 2 decades are as follows:

Achievement Trends

- Several demographic changes have taken place during the past 2 decades that could affect student achievement. For example, the proportion of all parents who had received at least some college education increased from 25 percent in 1970 to 49 percent in 1993. (See figure 1-5.) The trend held for white, black, and Hispanic parents, although in 1993, parents of Hispanic students still had less education than parents of white or black students. Additionally, the proportion of families with children younger than age 18 living with only one parent increased from only 13 percent in 1970 to 30 percent by 1993. (See figure 1-6.) At the same time, students were more likely to be living below the poverty level; the proportion of students between 6 and 17 years old living in poverty rose from 14 percent in 1970 to 20 percent in 1993. (See figure 1-7.)
- Student achievement in both science and mathematics, as measured by the NAEP trends, has increased since 1977. Although increases do not occur every year, they are clearly observable for students of every race and ethnic origin and at every age. Increases occurred in the percentage of students who attained at least a basic level of knowledge in science and mathematics, especially among blacks and Hispanics and those at the lowest achievement levels. For example, the percentage of 13-year-old black students who attained a proficiency score of 250 or more increased from 29 percent in 1978 to 51 percent in 1992—a 22-percentage-point increase in students who perform at acceptable levels of mathematics in the eighth grade.
- These gains have not eliminated the gaps between males and females. For example, in 1977, the largest gap between the percentage of males and the percentage of females scoring at selected NAEP anchor points was in science at age 17. The gap between the achievement of males and females had decreased from 14 percentage points in 1977 to 9 in 1992. (See figure 2-12.)
- Sharp differences in student mathematics performance among states in the United States match differences among countries. A comparison of international and state proficiencies shows, for example, that eighth-grade performance in the highest ranking states (Iowa, North Dakota, and Minnesota) was the same as in the top-performing countries (Taiwan, Korea, and the former Soviet Union), while performance in the lowest performing states was about the same as in the lowest performing countries. (See figure 2-19.)
- Overall, students in the Midwest had the highest NAEP mathematics scores, and students in the Southeast had the lowest scores. (See figure 2-19.)

Curriculum Trends

- High schools appear to be placing more emphasis on science and mathematics education. Whereas 20 percent of states required high school students to complete 2 or more years of mathematics in 1974, almost

90 percent of states had that requirement in 1992. (See figure 3-1.) However, requirements in all states remain below the 4 years of science and mathematics recommended by the national standards.

- Increasing proportions of high school students received instruction in science and mathematics in the past 10 years. (See figures 3-4, 3-5, and 3-6.) Also, elementary students spent more time in class studying science and mathematics. (See figure 3-2.)
- Between 1982 and 1992, female and male high school graduates had earned credit in all science and mathematics courses at about the same rate, except in physics, where rates for males significantly exceeded those for females. (See figure 3-4.)
- Substantial differences in coursetaking existed among students in various racial and ethnic groups. (See figures 3-5 and 3-6.) For example, while about the same proportion of white, black, and Hispanic high school graduates had earned credits in biology and introductory algebra in 1992, a significantly higher proportion of white graduates had completed courses in chemistry, physics, geometry, advanced algebra, and trigonometry.
- Ability grouping—assigning students to specific classes such as honors or remedial courses—in secondary science and mathematics classrooms has declined, creating a more heterogeneous environment. (See figure 3-8.) Whatever may have stimulated this change, it is a move toward greater classroom equity, since homogeneous classrooms may deprive low-achieving students of exposure to demanding coursework and the stimulation and encouragement to achieve.

Teachers

- High school science and mathematics teachers are likely to have completed their undergraduate training with majors in their teaching fields, but few elementary school teachers majored in science or mathematics. (See figure 3-21.) Only about two-thirds of teachers of grades 1 through 8 have completed at least one college course in the biological, physical, or earth sciences. (See figure 3-22.)
- Less than 30 percent of elementary school teachers say they feel well qualified to teach life science, while 60 percent feel well qualified to teach mathematics and close to 80 percent feel well qualified to teach reading. (See figure 3-28.)
- Overall, many teachers are not yet following recommendations for reforming classroom practice; for example, teachers have not implemented early introduction of algebraic concepts or alternative assessments. However, science and mathematics teachers are using more "hands-on" activities. The number of classes using hands-on activities increased in each grade level since 1986, following a decline since 1977. Still, fewer than 40 percent of junior high or high school classes used hands-on activities in their most recent lesson. (See figure 3-20.)

Postsecondary Trends

- As the value of postsecondary education has increased across all sectors of the economy, the percentage of high school students aspiring to obtain a bachelor's or higher degree has increased dramatically, regardless of sex, race, or ethnic origin. (See figure 4-2.)
- During the 1980s, despite decreases in the population of college-age youth, the number of bachelor's degree recipients increased markedly. The number of science and engineering bachelor's degree recipients also increased, although not as notably. However, compared with nations such as Japan, South Korea, and Germany, the United States graduates significantly fewer persons with first degrees in natural science and engineering. (See figure 4-16.)
- Although interest in science and engineering careers declines among students between 10th grade and college graduation, a large portion of science and engineering graduates actually enter their discipline during the final years of college. (See figure 4-13.)
- Although 28 percent of male and 10 percent of female high school seniors planned to major in one of the science or engineering fields, by the time they were college seniors, only 11 percent of males and 4 percent of females actually completed the major. (See text table 4-1.)
- Between 1971 and 1991, increases in graduate degrees awarded exceeded increases at the bachelor's level. By 1991, doctorates in science and engineering constituted almost two-thirds of all doctorates granted in the United States. During this period, universities awarded 39 percent more science and engineering master's degrees and 23 percent more science and engineering doctoral degrees. (See figure 4-18.)
- The number of females receiving bachelor's degrees in science and engineering has increased substantially in the past few years; while the number of males graduating in those fields has remained flat or declined. (See appendix table 4-18.) Still, while females constituted 54 percent of all bachelor's degree recipients in 1991, they earned only 44 percent of all bachelor's degrees in science and engineering.
- The number of blacks and Hispanics graduating with science or engineering bachelor's degrees increased

between 1985 and 1991. However, blacks represented only 6 percent of science and engineering bachelor's degree recipients, whereas they represented 14 percent of the postsecondary population. Hispanics represented 4 percent of science and engineering bachelor's degree recipients and 11 percent of the population.

- Underrepresentation is evident in the number of minorities and females who serve as science and engineering faculty members. In 1992, blacks made up about 5 percent of all higher education faculty, but they made up only 3 percent of natural sciences faculty and less than 3 percent in engineering. (See figure 4-29.) Similarly, although the number of women teaching in U.S. postsecondary institutions increased markedly, females account for only about 15 percent of faculty in the natural sciences and only about 6 percent of engineering faculty (see figure 4-30); they make up about one-third of all higher education faculty. ■